

**FIREARM LASER TRAINING SYSTEM AND METHOD FACILITATING FIREARM TRAINING WITH VARIOUS TARGETS AND VISUAL FEEDBACK OF SIMULATED PROJECTILE IMPACT LOCATIONS**

**1 CROSS-REFERENCE TO RELATED APPLICATIONS**

2 This application claims priority from U.S. Provisional Patent Application Serial Nos.  
3 60/210,595, entitled “Firearm Laser Training System and Method Facilitating Firearm  
4 Training with Various Targets” and filed June 9, 2000, and 60/260,522, entitled “Firearm  
5 Laser Training System and Method Facilitating Firearm Training With Visual Feedback of  
6 Simulated Projectile Impact Locations” and filed January 10, 2001. The disclosures of the  
7 above-mentioned provisional applications are incorporated herein by reference in their  
8 entireties.

9

**10 BACKGROUND OF THE INVENTION**

**11 Technical Field**

12 The present invention pertains to firearm training systems, such as those disclosed in  
13 U.S. Patent Application Serial Nos. 09/486,342, entitled “Network-Linked Laser Target  
14 Firearm Training System” and filed February 25, 2000; 09/761,102, entitled “Firearm  
15 Simulation and Gaming System and Method for Operatively Interconnecting a Firearm  
16 Peripheral to a Computer System” and filed January 16, 2001; 09/760,610, entitled “Laser  
17 Transmitter Assembly Configured For Placement Within a Firing Chamber and Method of  
18 Simulating Firearm Operation” and filed January 16, 2001; 09/760,611, entitled “Firearm  
19 Laser Training System and Method Employing Modified Blank Cartridges for Simulating  
20 Operation of a Firearm” and filed January 16, 2001; 09/761,170, entitled “Firearm Laser  
21 Training System and Kit Including a Target Having Sections of Varying Reflectivity for  
22 Visually Indicating Simulated Projectile Impact Locations” and filed January 16, 2001; and  
23 09/862,187, entitled “Firearm Laser Training System and Method Employing an Actuable  
24 Target Assembly” and filed May 21, 2001. The disclosures of the above-mentioned patent  
25 applications are incorporated herein by reference in their entireties. In particular, the present

1 invention pertains to a firearm laser training system that accommodates various targets for  
2 facilitating a variety of firearm training activities.

3

4 Discussion of the Related Art

5 Firearms are utilized for a variety of purposes, such as hunting, sporting competition,  
6 law enforcement and military operations. The inherent danger associated with firearms  
7 necessitates training and practice in order to minimize the risk of injury. However, special  
8 facilities are required to facilitate practice of handling and shooting the firearm. These special  
9 facilities tend to provide a sufficiently sized area for firearm training and/or confine projectiles  
10 propelled from the firearm within a prescribed space, thereby preventing harm to the  
11 surrounding environment. Accordingly, firearm trainees are required to travel to the special  
12 facilities in order to participate in a training session, while the training sessions themselves  
13 may become quite expensive since each session requires new ammunition for practicing  
14 handling and shooting of the firearm.

15 In addition, firearm training is generally conducted by several organizations (e.g.,  
16 military, law enforcement, firing ranges or clubs, etc.). Each of these organizations may have  
17 specific techniques or manners in which to conduct firearm training and/or qualify trainees.

18 Accordingly, these organizations tend to utilize different types of targets, or may utilize a  
19 common target, but with different scoring criteria. Further, different targets may be employed  
20 by users for firearm training or qualification to simulate particular conditions or provide a  
21 specific type of training (e.g., grouping shots, hunting, clay pigeons, etc.).

22 The related art has attempted to overcome the above-mentioned problems by utilizing  
23 laser or light energy with firearms to simulate firearm operation and indicate simulated  
24 projectile impact locations on targets. For example, U.S. Patent No. 4,164,081 (Berke)  
25 discloses a marksman training system including a translucent diffuser target screen adapted  
26 for producing a bright spot on the rear surface of the target screen in response to receiving a  
27 laser light beam from a laser rifle on the target screen front surface. A television camera scans  
28 the rear side of the target screen and provides a composite signal representing the position of  
29 the light spot on the target screen rear surface. The composite signal is decomposed into X  
30 and Y Cartesian component signals and a video signal by a conventional television signal  
31 processor. The X and Y signals are processed and converted to a pair of proportional analog  
32 voltage signals. A target recorder reads out the pair of analog voltage signals as a point, the

1 location of which is comparable to the location on the target screen that was hit by the laser  
2 beam.

3 U.S. Patent No. 5,281,142 (Zaenglein, Jr.) discloses a shooting simulation training  
4 device including a target projector for projecting a target image in motion across a screen, a  
5 weapon having a light projector for projecting a spot of light on the screen, a television  
6 camera and a microprocessor. An internal device lens projects the spot onto a small internal  
7 device screen that is scanned by the camera. The microprocessor receives various information  
8 to determine the location of the spot of light with respect to the target image.

9 U.S. Patent No. 5,366,229 (Suzuki) discloses a shooting game machine including a  
10 projector for projecting a video image that includes a target onto a screen. A player may fire  
11 a laser gun to emit a light beam toward the target on the screen. A video camera photographs  
12 the screen and provides a picture signal to coordinate computing means for computing the X  
13 and Y coordinates of the beam point on the screen.

14 International Publication No. WO 92/08093 (Kunnecke et al.) discloses a small arms  
15 target practice monitoring system including a weapon, a target, a light-beam projector  
16 mounted on the weapon and sighted to point at the target and a processor. An evaluating unit  
17 is connected to the camera to determine the coordinates of the spot of light on the target. A  
18 processor is connected to the evaluating unit and receives the coordinate information. The  
19 processor further displays the spot on a target image on a display screen.

20 The systems described above suffer from several disadvantages. In particular, the  
21 Berke, Zaenglein, Jr. and Suzuki systems employ particular targets or target scenarios, thereby  
22 limiting the types of firearm training activities and simulated conditions provided by those  
23 systems. Further, the Berke system utilizes both front and rear target surfaces during  
24 operation. Thus, placement of the target is restricted to areas having sufficient space for  
25 exposure of those surfaces to a user and the system. The Zaenglein, Jr. and Suzuki systems  
26 employ a video projector, a video camera and associated components for operation, thereby  
27 increasing system complexity and costs. In addition, the Berke and Kunnecke et al. systems  
28 merely display impact locations to a user, thereby requiring a user to interpret the display to  
29 assess user performance during an activity. The assessment is typically limited to the  
30 information provided on the display, thereby restricting feedback of valuable training  
31 information to the user and limiting the training potential of the system.

32 **OBJECTS AND SUMMARY OF THE INVENTION**

1        Accordingly, it is an object of the present invention to accommodate various types of  
2 targets within a firearm laser training system to conduct varying types of training, qualification  
3 and/or entertainment activities.

4        It is another object of the present invention to easily calibrate a firearm laser training  
5 system prior to and during use.

6        Yet another object of the present invention is to employ user-specified targets within  
7 a firearm laser training system to conduct desired training procedures.

8        A further object of the present invention is to assess user performance within a firearm  
9 laser training system by determining scoring and/or other performance information based on  
10 detected impact locations of simulated projectiles on a target.

11       The aforesaid objects are achieved individually and/or in combination, and it is not  
12 intended that the present invention be construed as requiring two or more of the objects to be  
13 combined unless expressly required by the claims attached hereto.

14       According to the present invention, a firearm laser training system includes a target  
15 having a plurality of zones, a laser transmitter assembly that attaches to a firearm, a sensing  
16 device configured to scan the target and detect beam impact locations thereon, and a processor  
17 in communication with the sensing device. The processor displays an image of the target  
18 including detected impact locations and further evaluates user performance by providing  
19 scoring and/or other information that is based on the detected impact locations. The sensing  
20 device may be configured to determine coordinate information associated with each detected  
21 impact location and send those coordinates to the processor for further processing.  
22 Alternatively, the sensing device may be configured to send an image to the processor at  
23 selected time intervals, where the processor determines impact location coordinates from the  
24 image information received from the sensing device. The firearm laser training system of the  
25 present invention accommodates various types of targets to facilitate a variety of firearm  
26 training, qualification and/or entertainment activities. In addition, the system may be compact  
27 and portable to facilitate ease of use in a variety of different environments.

28       The above and still further features and advantages of the present invention will  
29 become apparent upon consideration of the following detailed description of specific  
30 embodiments thereof, particularly when taken in conjunction with the accompanying drawings  
31 wherein like reference numerals in the various figures are utilized to designate like  
32 components.

1                   **BRIEF DESCRIPTION OF THE DRAWINGS**

2                   Fig. 1 is a view in perspective of a firearm laser training system having a laser beam  
3 directed from a firearm onto a target according to the present invention.

4                   Fig. 2 is an exploded view in perspective and partial section of a laser transmitter  
5 assembly of the system of Fig. 1 fastened to a firearm barrel.

6                   Fig. 3 is a procedural flow chart illustrating the manner in which the system of Fig. 1  
7 processes and displays laser beam impact locations according to the present invention.

8                   Fig. 4 is a schematic illustration of an exemplary graphical user screen displayed by  
9 the system of Fig. 1 for firearm activities.

10                  Fig. 5 is a view in perspective of a firearm laser training system having a laser  
11 beam directed from a firearm onto a target according to an alternative embodiment of the  
12 present invention.

13                  Fig. 6 is a procedural flow chart illustrating the manner in which the system of Fig.  
14 5 processes and displays laser beam impact locations according to the present invention.

15                  Figs. 7 - 8 are schematic illustrations of exemplary graphical user screens displayed  
16 by the system of Fig. 5 during system operation.

17                   **DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS**

18                  A firearm laser training system that accommodates various types of targets according  
19 to the present invention is illustrated in Fig. 1. Specifically, the firearm laser training system  
20 includes a laser transmitter assembly 2, a target 10, an image sensing device 16 and a  
21 computer system 18. The laser assembly is attached to an unloaded user firearm 6 to adapt  
22 the firearm for compatibility with the training system. By way of example only, firearm 6 is  
23 implemented by a conventional hand-gun and includes a trigger 7, a barrel 8, a hammer 9 and  
24 a grip 15. However, the firearm may be implemented by any conventional firearms (e.g.,  
25 hand-gun, rifle, shotgun, etc), while the laser and firearm combination may be implemented  
26 by any of the simulated firearms disclosed in the above-mentioned patent applications. Laser  
27 assembly 2 includes a laser transmitter rod 3 and a laser transmitter module 4 that emits a  
28 beam 11 of visible laser light in response to actuation of trigger 7. Rod 3 is connected to  
29 module 4 and is configured for insertion within barrel 8 to fasten the laser assembly to the  
30 barrel as described below. A user aims unloaded firearm 6 at target 10 and actuates trigger  
31 7 to project laser beam 11 from laser module 4 toward the target. Sensing device 16 detects  
32

1 the laser beam impact location on the target and provides location information to computer  
2 system 18. The computer system processes the location information and displays simulated  
3 projectile impact locations on a scaled target via a graphical user screen (Fig. 4) as described  
4 below. In addition, the computer system determines scoring and other information based upon  
5 the performance of a user.

6 The system may be utilized with various types of targets to facilitate firearm training  
7 and/or qualifications (e.g., certification to a particular level or to use a particular firearm). The  
8 system may additionally be utilized for entertainment purposes (e.g., in target shooting games  
9 or sporting competitions). By way of example only, target 10 is implemented by a two-  
10 dimensional target, preferably constructed of paper or other material, and attached to or  
11 suspended from a supporting structure, such as a wall. The target includes indicia forming  
12 a transitional type target having a silhouette of a person with several sections or zones (e.g.,  
13 typically between five and seven) defined therein. The target sections are each typically  
14 assigned a value in order to determine a score for a user. The sections and values typically  
15 vary based on the system application and/or particular organization (e.g., military, law  
16 enforcement, firearm club, etc.) utilizing the system. Further, plural target sections (e.g.,  
17 contiguous or non-contiguous) may be associated with a common value, while each section  
18 may be of any shape or size. The score is determined by accumulating the values of the target  
19 sections impacted by the laser beam during the firearm activity. The values of the target  
20 sections may further be multiplied by a scoring factor set by the system and/or the user to  
21 accommodate various scoring schemes utilized by different organizations. The computer  
22 system receives the beam impact locations from the sensing device and retrieves the section  
23 values corresponding to the impact locations as described below. Section values for each  
24 beam impact are accumulated to produce a score for a user. The target may be of any shape  
25 or size, may be constructed of any suitable materials and may include any indicia to provide  
26 any type of target for facilitating any type of training, qualification, gaming, entertainment or  
27 other activity. Moreover, the system may utilize any conventional, simulated or “dry fire”  
28 type firearms (e.g., hand-gun, rifle, shotgun, firearms powered by air/carbon dioxide, etc.), or  
29 firearms utilizing blank cartridges such as those disclosed in the above-mentioned patent  
30 applications, for projecting a laser beam to provide full realism in a safe environment.

31 An exemplary laser transmitter assembly employed by the training system is illustrated  
32 in Fig. 2. Specifically, laser assembly 2 includes laser transmitter rod 3 and laser transmitter

1 module 4. Rod 3 includes a generally cylindrical barrel member 17 and a stop 19 disposed  
2 at the barrel member distal end. The barrel member is elongated with a tapered proximal end  
3 and has transverse cross-sectional dimensions that are slightly less than the internal cross-  
4 sectional dimensions of barrel 8 to enable the barrel member to be inserted within the barrel.  
5 However, the barrel member may be of any shape or size to accommodate firearms of various  
6 calibers. Adjustable rings 72, 74 are disposed about the barrel member toward its proximal  
7 and distal ends, respectively. The dimensions of each ring are adjustable to enable barrel  
8 member 17 to snugly fit within and frictionally engage barrel 8 in a secure manner. Stop 19  
9 is in the form of a substantially circular disk having a diameter slightly greater than the cross-  
10 sectional dimensions of barrel 8 to permit insertion of rod sections proximal of the stop into  
11 the barrel. The stop may alternatively be of any shape or size capable of limiting insertion of  
12 the rod into the barrel. Barrel member 17 is connected to the approximate center of stop 19,  
13 while a post 21 is attached to and extends distally for a slight distance from an approximate  
14 center of a stop distal surface. Post 21 is substantially cylindrical and has transverse cross-  
15 sectional dimensions similar to those of barrel member 17, but may be of any shape or size.  
16 The post includes external threads 23 for facilitating engagement with laser module 4 as  
17 described below.

18       Laser module 4 includes a housing 25 having an internally threaded opening 38  
19 defined in an upper portion of a housing rear wall for receiving post 21 and attaching the laser  
20 module to rod 3. The housing and opening may be of any shape or size, while the opening  
21 may be defined in the housing at any suitable location. The laser module components are  
22 disposed within the housing and include a power source 27, typically in the form of batteries,  
23 a mechanical wave sensor 29 and an optics package 31 having a laser (not shown) and a lens  
24 33. These components may be arranged within the housing in any suitable fashion. The  
25 optics package emits laser beam 11 through lens 33 toward target 10 or other intended target  
26 in response to detection of trigger actuation by mechanical wave sensor 29. Specifically,  
27 when trigger 7 is actuated, hammer 9 impacts the firearm and generates a mechanical wave  
28 which travels distally along barrel 8 toward rod 3. As used herein, the term "mechanical  
29 wave" or "shock wave" refers to an impulse traveling through the firearm barrel. Mechanical  
30 wave sensor 29 within the laser module senses the mechanical wave from the hammer impact  
31 and generates a trigger signal. The mechanical wave sensor may include a piezoelectric  
32 element, an accelerometer or a solid state sensor, such as a strain gauge. Optics package 31

1 within the laser module generates and projects laser beam 11 from firearm 6 in response to  
2 the trigger signal. The optics package laser is generally enabled for a predetermined time  
3 interval sufficient for the sensing device to detect the beam. The beam may be coded,  
4 modulated or pulsed in any desired fashion. Alternatively, the laser module may include an  
5 acoustic sensor to sense actuation of the trigger and enable the optics package. The laser  
6 module is similar in function to the laser devices disclosed in the aforementioned patent  
7 applications. The laser assembly may be constructed of any suitable materials and may be  
8 fastened to firearm 6 at any suitable location by any conventional or other fastening technique.

9 Referring back to Fig. 1, computer system 18 is coupled to and receives and processes  
10 information from sensing device 16 to provide various feedback to a user. The computer  
11 system is typically implemented by a conventional IBM-compatible laptop or other type of  
12 personal computer (e.g., notebook, desk top, mini-tower, Apple Macintosh, palm pilot, etc.)  
13 preferably equipped with display or monitor 34, a base 32 (i.e., including the processor,  
14 memories, and internal or external communication devices or modems) and a keyboard 36  
15 (e.g., including a mouse or other input device). Computer system 18 includes software to  
16 enable the computer system to communicate with sensing device 16 and provide feedback to  
17 the user. The computer system may utilize any of the major platforms (e.g., Linux, Macintosh,  
18 Unix, OS2, etc.), but preferably includes a Windows environment (e.g., Windows 95, 98, NT,  
19 or 2000). Further, the computer system includes components (e.g. processor, disk storage or  
20 hard drive, etc.) having sufficient processing and storage capabilities to effectively execute  
21 the system software. By way of example only, computer system 18 includes a pentium or  
22 compatible processor and at least sixteen megabytes of RAM.

23 Computer system 18 is connected to sensing device 16 via a cable and preferably  
24 utilizes an RS-232 type interface. The sensing device may be mounted on a tripod and  
25 positioned at a suitable location from the target. However, any type of mounting or other  
26 structure may be utilized to support the sensing device. The sensing device is typically  
27 implemented by a camera employing charge-coupled devices (CCD), but may be implemented  
28 by any type of light sensing grid array or element matrix. The sensing device detects the  
29 location of beam impact on the target (e.g., by capturing an image of the target and detecting  
30 the location of the beam impact from the captured image) and includes a signal processor and  
31 associated circuitry to provide impact location information in the form of X and Y coordinates  
32 to computer system 18, or provide other data to the computer system to enable determination

1 of those coordinates. By way of example only, the sensing device may be similar to the image  
2 sensing devices disclosed in U.S. Patent Nos. 5,181,015 (Marshall et al.), 5,400,095 (Minich  
3 et al.), 5,489,923 (Marshall et al.), 5,502,459 (Marshall et al.), 5,504,501 (Hauck et al.),  
4 5,515,079 (Hauck), 5,594,468 (Marshall et al.) and 5,933,132 (Marshall et al.), the disclosures  
5 of which are incorporated herein by reference in their entireties. However, the computer  
6 system may utilize any type of input device providing impact location or other information  
7 (e.g., a mouse to simulate firearm operation). The computer system instructs the sensing  
8 device to perform a calibration to correlate the target with a scaled target space utilized by the  
9 sensing device as described below. The calibration essentially defines the target space to the  
10 sensing device to enable the sensing device and/or computer system to correlate beam impact  
11 locations on the target with X and Y coordinates within the scaled target space (e.g., correlate  
12 the target field or plane with the sensing device field or plane). The resulting coordinates or  
13 location information is transmitted to the computer system for translation to coordinates  
14 within the computer system's scaled target spaces to facilitate scoring and display of beam  
15 impact locations as described below. A printer (not shown) may further be connected to the  
16 computer system to print reports containing user feedback information (e.g., score, hit/miss  
17 information, etc.). The computer system and/or sensing device may determine X and Y  
18 coordinate information corresponding to beam impact locations from any type of information.

19 The system may be utilized with various types of targets. Target characteristics are  
20 contained in several files that are stored by computer system 18. In particular, a desired target  
21 may be photographed and/or scanned prior to system utilization to produce several target files  
22 and target information. Alternatively, images of user generated targets may be captured via  
23 sensing device 16 and optionally manipulated to form a target image, while computer system  
24 18 or other computer system (e.g., via training system or conventional software) may be  
25 utilized to produce the target files and target information for use by the system. A target file  
26 includes a parameter file, a display image file, a scoring image file and a print image file. The  
27 parameter file includes information to enable the computer system to control system  
28 operation. By way of example only, the parameter file includes the filenames of the display,  
29 scoring and print image files, a scoring factor and cursor information (e.g., grouping criteria,  
30 such as circular shot group size). The display and print image files include an image of the  
31 target scaled to particular sections of the monitor and report containing that image,  
32 respectively. Indicia, preferably in the form of substantially circular icons, are overlaid on

1 these images to indicate beam impact locations, and typically include an identifier to indicate  
2 the particular shot (e.g., the position number of the shot within a shot sequence). The  
3 dimensions of the indicia may be adjusted to simulate different ammunition or firearm calibers  
4 entered by a user. The scoring image file includes a scaled scoring image of the target having  
5 scoring sections or zones shaded with different colors. Any variation of colors may be  
6 utilized, and the colors are each associated with corresponding information associated with  
7 that zone. The zone information typically includes scoring values, but may include any other  
8 types of activity information (e.g., target number, desirable/undesirable hit location, priority  
9 of hit location, friend/foe, etc.). When impact location information is received from the  
10 sensing device, computer system 18 translates that information to coordinates within the  
11 scoring image. The color associated with the image location identified by the translated  
12 coordinates indicates a corresponding zone and/or scoring value. In effect, the colored scoring  
13 image functions as a look-up table to provide a zone value based on coordinates within the  
14 scoring image pertaining to a particular beam impact location. The scoring value of an impact  
15 location may be multiplied by a scoring factor within the parameter file to provide scores  
16 compatible with various organizations and/or scoring schemes. Thus, the scoring of the  
17 system may be adjusted by modifying the scoring factor within the parameter file and/or the  
18 scoring zones on the scoring image within the scoring image file. Alternatively, when other  
19 activity information is associated with the zones, the scoring image file may indicate  
20 occurrence of various events (e.g., hit/miss of target locations, target sections impacted based  
21 on priority, hit friend or foe, etc.) in substantially the same manner described above.

22 In addition, the target files typically include a second display file containing a scaled  
23 image of the target. The dimensions of this image are substantially greater than those of the  
24 image contained in the initial display image file, and the second display file is preferably  
25 utilized to display a target having plural independent target sites. The target files along with  
26 scaling and other information (e.g., target range information input by user) are stored on  
27 computer system 18 for use during system operation. An initial calibration is performed to  
28 correlate the target with the sensing device and computer system. This calibration may be  
29 performed manually or automatically as described below. Thus, the system may readily  
30 accommodate any type of target without interchanging system components. Moreover, target  
31 files may be downloaded from a network, such as the Internet, and loaded into the computer  
32 system to enable the system to access and be utilized with additional targets.

1           Sensing device 16 may alternatively be implemented by an image capture and sensing  
2 device that may include a removable filter and operate in a learning mode and a training mode.  
3           The learning mode is utilized without the filter to capture and produce an image of a desired  
4 target. The sensing device initially captures a target image and modifies the image to correct  
5 for geometrical offsets, optics and lighting variances, and performs other image enhancement  
6 techniques. The enhanced image is provided to the computer system for display, and  
7 corresponds with increased accuracy to the target. Scaling and other information is also  
8 provided to or by the computer system to facilitate translations of received beam impact  
9 location coordinates and scoring as described above, thereby minimizing calibration.

10          When the system is utilized, the filter (e.g., an approximate 650 nanometer bandpass  
11 filter is placed) is placed over the sensing device to filter incoming light signals and to enable  
12 the device to detect laser beam impact locations in response to user actuation of the firearm.  
13          The sensing device provides X and Y coordinates or other location information to the  
14 computer system to display the impact location and determine scoring and other information  
15 as described above. The sensing device may be adjusted or calibrated at specific time  
16 intervals (e.g., twenty minutes, fifty minutes, etc.) or in response to particular events (e.g.,  
17 initiation of a session, termination of a session, etc.). Specifically, the computer system may  
18 perform a calibration or may command the sensing device to perform the calibration with or  
19 without the filter. An image is captured and verified for consistency with the previously  
20 captured image. When the images are inconsistent, the new image is enhanced and utilized  
21 as described above.

22          Computer system 18 includes software to control system operation and provide a  
23 graphical user interface for displaying user performance. The manner in which the computer  
24 system monitors beam impact locations and provides information to a user is illustrated in  
25 Figs. 3 - 4. Initially, computer system 18 (Fig. 1) directs the sensing device to perform a  
26 calibration at step 40. The sensing device basically defines a target area within a grid array  
27 (e.g., 8192 by 8192 pixels) in response to the user projecting the laser beam at one or more  
28 specified target locations. For example, the sensing device may prompt the user via computer  
29 system 18 to successively project the laser beam at the target corners. The beam is detected  
30 by the sensing device, while the impact locations define the target area. Alternatively, any  
31 other technique may be utilized to identify and reference the target area (e.g., projecting a  
32 single laser beam at the target center, providing indicia on the target at known coordinate

1 locations, etc.). The target area is mapped to the grid array to facilitate providing beam impact  
2 location coordinates within the array to computer system 18 as described below. The  
3 calibration is typically performed at system initialization, but may be initiated by a user via  
4 computer system 18.

5 Once the system is calibrated, a user may commence projecting the laser beam from  
6 the firearm toward the target. Sensing device 16 detects the laser beam impact location on  
7 the target at step 42, and determines the X and Y coordinates within the device grid array  
8 corresponding to the beam impact location at step 44. The impact location coordinates are  
9 subsequently transmitted to computer system 18 for processing at step 46. The computer  
10 system includes several target files having target information and scaled images as described  
11 above. Since the scaling of the scoring and display images and sensing device array are  
12 predetermined, the computer system translates the received grid array coordinates into the  
13 respective scoring and display image coordinate spaces at step 48. Basically, the sensing  
14 device grid array and scoring and display images each utilize a particular quantity of pixels  
15 for a given measurement unit (e.g., millimeter, centimeter, etc.). The ratios of these pixel  
16 quantities between the grid array and each of the scoring and display images are determined  
17 and applied to the received coordinates to produce translated coordinates within each of the  
18 respective scoring and display image coordinate spaces. The received and/or translated  
19 coordinates may be further processed and/or manipulated to determine fine calibration  
20 adjustments, ballistics or other factors related to specific applications.

21 The translated coordinates for the scoring image are utilized to determine the score for  
22 the beam impact at step 50. Specifically, the translated coordinates identify a particular  
23 location within the scoring image. When zones are associated with scoring information,  
24 various sections of the scoring image are color coded to indicate a scoring value associated  
25 with that section as described above. The color of the location within the scoring image  
26 identified by the translated coordinates is ascertained to indicate the scoring value for the  
27 beam impact. The scoring factor within the parameter file is applied to (e.g., multiplied by)  
28 the scoring value to determine a score for the beam impact. The score and other impact  
29 information is determined and stored in a database or other storage structure, while a computer  
30 system display showing the target is updated to illustrate the beam impact location and other  
31 information (e.g., natural dispersion, mean point of impact, offset of impact from center of  
32 target, such as quantity of units above, below, left or right of target, impact score, cumulative

1 score, etc.) at step 52. The display image is displayed on the computer monitor and includes  
2 the beam impact location as identified by indicia that are overlaid with the display image and  
3 placed in an area encompassing the translated display image coordinates. An exemplary  
4 graphical user screen indicating the target, beam impact locations, impact time, score and  
5 other information is illustrated in Fig. 4.

6 If a round or session of firearm activity is not complete as determined at step 54, the  
7 user continues actuation of the firearm and the system detects beam impact locations and  
8 determines information as described above. However, when a round or session is determined  
9 to be complete at step 54, the computer system retrieves information from the database and  
10 determines information pertaining to the round at step 56. The computer system may further  
11 determine grouping circles. These are generally utilized on shooting ranges where projectile  
12 impacts through a target must all be within a circle of a particular diameter (e.g., four  
13 centimeters). The computer system may analyze the beam impact information and provide  
14 groupings and other information on the display that is typically obtained during activities  
15 performed on firing ranges (e.g., dispersion, etc.). The grouping circle and beam impact  
16 location indicia are typically overlaid with the display image and placed in areas  
17 encompassing the appropriate coordinates of the display image space in substantially the same  
18 manner described above.

19 When a report is desired as determined at step 58, the computer system retrieves the  
20 appropriate information from the database and generates a report for printing at step 60. The  
21 report includes the print image, while beam impact location coordinates are retrieved from the  
22 database and translated to the print image coordinate space. The translation is accomplished  
23 utilizing ratios of pixel quantities for a given measurement unit between the sensing device  
24 grid array and the print image in substantially the same manner described above. The beam  
25 impact locations are identified by indicia that are overlaid with the print image and placed in  
26 an area encompassing the translated print image coordinates as described above for the  
27 display. The report further includes various information pertaining to user performance (e.g.,  
28 score, dispersion, mean point of impact, offset from center, etc.). When another round is  
29 desired, and a calibration is requested at step 64, the computer system commands the sensing  
30 device to perform the calibration at step 40 and the above process of system operation is  
31 repeated. Similarly, the above process of system operation is repeated from step 42 when  
32 another round is desired without performing a calibration. System operation terminates upon

1 completion of the training or qualification activity as determined at step 62.

2       The system may additionally provide a tracing feature to assist in verifying calibration  
3 and providing information to a user with respect to firearm movement during aiming and  
4 actuation. In particular, the trace feature is enabled in response to the laser transmitter  
5 assembly operating in a “constant on” mode. When the sensing device detects the laser beam  
6 continuously for approximately one and one-half seconds, the computer system displays a  
7 flashing block on the graphical user screen. The block follows movement of the firearm or  
8 laser beam projected on the target. Basically, the computer system polls the sensing device  
9 for coordinates of the laser beam impact location at frequent time intervals. The coordinates  
10 are translated by the computer system as described above and the position of the block is  
11 adjusted on the display in accordance with the translated coordinates. As the firearm or laser  
12 beam alters position, the block is similarly adjusted on the display to visually indicate  
13 movement of the firearm.

14       Operation of the system is described with reference to Fig. 1. Initially, a target is  
15 selected and placed on a supporting structure, while corresponding target files containing  
16 target information are produced and stored in the computer system. Laser transmitter rod 3  
17 is connected to laser module 4 and inserted into barrel 8 of firearm 6 as described above. The  
18 laser module is actuated in response to depression of firearm trigger 7. Any of the lasers or  
19 firearms disclosed in the above-mentioned patent applications may be utilized (e.g., systems  
20 employing dry fire weapons, air/carbon dioxide powered weapons and/or weapons utilizing  
21 blank cartridges, etc.). The computer system is commanded to commence a firearm activity,  
22 and initially instructs the sensing device to perform a calibration as described above. The user  
23 aims the firearm at the target and depresses the trigger to project a laser beam at specified  
24 locations on the target to enable the sensing device to perform the calibration. Once the  
25 sensing device is calibrated, and in response to firearm actuation by a user, the sensing device  
26 detects beam impact locations on the target and provides impact location information in the  
27 form of X and Y coordinates to the computer system as described above. The computer  
28 system translates the received coordinates into the respective scoring and display image spaces  
29 and further determines a value corresponding to the impacted target section and other  
30 information for storage in a database as described above. The impact location and other  
31 information are displayed on a graphical user screen (Fig. 4) as described above. When a  
32 round is complete, the computer system retrieves the stored information and determines

1 information pertaining to the round for display on the graphical user screen. Moreover, a  
2 report may be printed providing information relating to user performance as described above.  
3 In addition, the system may provide indicia on the display to indicate and trace firearm  
4 movement as described above. Alternatively, the sensing device may capture the target image  
5 and provide target information to the computer system to minimize calibrations as described  
6 above.

7 An alternative embodiment of the present invention is illustrated in Fig. 5.  
8 Specifically, the firearm laser training system includes laser transmitter assembly 2, a target  
9 100 and an image sensing device 116. These and other system components are preferably  
10 stored within a system case 180 as described below. The laser transmitter assembly is  
11 substantially similar to and operates in a substantially similar manner as the laser transmitter  
12 assembly described above. In order to facilitate system operation, the image sensing device  
13 is connected to user computer system 118 having training system software installed thereon,  
14 while the laser assembly is attached to unloaded user firearm 6 in substantially the same  
15 manner described above to adapt the firearm for compatibility with the training system. When  
16 a user aims firearm 6 at target 100 and actuates trigger 7, a laser beam 11 is projected from  
17 laser module 4 toward the target. Sensing device 116 captures images of the target and  
18 provides target image information to computer system 118 as described below. The computer  
19 system processes the target image information and displays simulated projectile impact  
20 locations on a scaled target via a graphical user screen (Fig. 8) as described below. In  
21 addition, the computer system determines scoring and other information pertaining to the  
22 performance of a user.

23 The alternative system may be utilized with various types of targets to facilitate  
24 firearm training. By way of example only, target 100 is illustrated as a bulls eye type target,  
25 preferably constructed of paper or other material and having a plurality of substantially  
26 concentric circles 141 and substantially diametric horizontal and vertical quadrant dividing  
27 lines 143, 145. The target is suspended from system case 180 as described below. The target  
28 includes several sections or zones defined therein (e.g., between the concentric circles, etc.).  
29 The target sections are each typically assigned a value in order to determine a score for a user.  
30 However, the sections may be associated with other activity information to facilitate  
31 determination of various impact characteristics as described above. The sections and values  
32 typically vary based on the system application. Further, plural target sections (e.g., contiguous

1 or non-contiguous) may be associated with a common value, while each section may be of any  
2 shape or size. The score is determined by accumulating the values of the target sections  
3 impacted by the laser beam during the firearm activity. The computer system receives target  
4 image information from the sensing device and determines the beam impact locations to  
5 retrieve the section values corresponding to those impact locations as described below.  
6 Section values for each beam impact are accumulated to produce a score for a user. The target  
7 may be of any shape or size, may be constructed of any suitable materials and may include any  
8 indicia to provide any type of target for facilitating any type of training. Moreover, the system  
9 may be utilized with any of the conventional, simulated or “dry fire” type firearms described  
10 above.

11 System case 180 includes upper and lower members 182, 184 pivotally connected to  
12 each other by hinges or other pivoting mechanisms. The lower member includes an open top  
13 portion and generally rectangular front, rear and side walls that collectively define the lower  
14 member interior or storage area. Similarly, upper member 184 includes an open bottom  
15 portion and generally rectangular front, rear and side walls that collectively define the upper  
16 member interior or storage area. The hinges or pivoting mechanisms are typically attached  
17 to the upper and lower member rear walls, while the lower member front wall or surface  
18 includes fasteners 190 that selectively engage corresponding fastening members 191 disposed  
19 on the upper member front wall or surface to secure the case in a closed state. Further, a  
20 handle 192 is disposed on the lower member front wall or surface between fasteners 190 to  
21 enable transport of the system case, thereby providing a portable system that may be utilized  
22 at virtually any suitable location. A support member 193 is connected between the upper and  
23 lower members to enable the case to maintain an open state with the upper member positioned  
24 at any desired angle relative to the lower member. This enables target 100 to be visible to a  
25 user and reduces glare from ambient light within the surrounding environment as described  
26 below.

27 The system case typically houses system components to enable the system to be  
28 available as a self-contained, portable unit. Specifically, lower member 184 includes  
29 insulation material, such as foam, configured to form several compartments each for receiving  
30 a corresponding system component. The compartments typically contain sensing device 116  
31 and corresponding sensing device stands (not shown), a cable 194 for connecting the sensing  
32 device to computer system 118 and laser transmitter assembly 2 and a corresponding tool

1 (e.g., an Allen wrench; not shown) to adjust the laser transmitter assembly for attachment to  
2 firearm 6. The lower member may further house additional targets, system software and/or  
3 documentation, a mock firearm (e.g., compressed air firearm) or any other additional system  
4 components or accessories.

5 Upper member 182 supports target 100 and includes a substantially rectangular flap  
6 189 having one side edge attached to the upper member interior surface to serve as a pivot  
7 point for the flap. The remaining flap edges are removably fastened to the upper member  
8 interior surface via hook and loop fasteners (e.g., velcro) or other conventional fastening  
9 devices to receive, secure and support target 100 within the upper member. The flap has  
10 dimensions sufficient to engage the target perimeter and includes an open central portion to  
11 enable viewing of the target by a system user. A substantially transparent diffuser 188 may  
12 be disposed between the target and flap to diffuse the emitted beam and enlarge the beam on  
13 the target. The diffuser further reduces glare from ambient light within the surrounding  
14 environment. In addition, the upper member is typically positioned at a particular angle  
15 relative to the lower member (e.g., preferably between the approximate range of eighty to  
16 ninety degrees) to similarly reduce glare from ambient light. This enhances detection of the  
17 beam impact location by the sensing device and computer system.

18 The system case is generally available with sensing device 116 and corresponding  
19 sensing device stands, cable 194, laser transmitter assembly 2 and corresponding tool, a  
20 plurality of interchangeable targets (e.g., bull's-eye, silhouette, and deer or other animal  
21 optionally designating a particular target area or "kill" shot) and system software and  
22 documentation. However, the case may include any system components or accessories and  
23 be arranged in any desired fashion. A user basically positions the case at a suitable location  
24 and opens the case to place a desired target and the diffuser within the flap. The laser  
25 transmitter is removed from the case and attached to the user firearm, while the software is  
26 installed on user computer system 118 (e.g., if the software is not currently resident on the  
27 computer system). The sensing device is positioned relative to the target and connected to the  
28 computer system via the cable. Once the software is executed, the system may simulate  
29 firearm operation as described below. Thus, the present invention provides a portable, self-  
30 contained unit compatible with virtually any firearm and facilitating firearm training at various  
31 locations.

32 Computer system 118 is substantially similar to the computer system described above

1 and preferably includes a monitor 134, base 132 (e.g., including the processor, memories,  
2 internal or external communication devices or modems, sound devices, etc.) and keyboard  
3 136 (e.g., including a mouse or other input device). The computer system is coupled to  
4 sensing device 116 and includes software to enable the computer system to communicate with  
5 and receive and process information from sensing device 116 to provide various feedback to  
6 a user. The computer system may utilize any of the major platforms (e.g., Linux, Macintosh,  
7 Unix, OS2, etc.), but preferably includes a Windows environment (e.g., Windows 95, 98, NT,  
8 or 2000). Further, the computer system includes components (e.g. processor, disk storage or  
9 hard drive, etc.) having sufficient processing (e.g., preferably at least a 300 MHZ processor)  
10 and storage capabilities (e.g., preferably at least 32 MB of RAM) to effectively execute the  
11 system software.

12 Sensing device 116 is preferably connected to a Universal Serial Bus (USB) port of  
13 computer system 118 via cable 194. The sensing device is typically implemented by a sensory  
14 image type camera employing charge-coupled devices (CCD) or CMOS. However, the  
15 sensing device may be implemented by any type of light or image sensing device and may be  
16 connected to computer system 118 via any type of port (e.g., serial, parallel, USB, etc.). The  
17 sensing device typically has a speed or rate of thirty frames per second and repeatedly captures  
18 an image of the target and provides target image information to the computer system at that  
19 rate. In other words, an image of the target is captured by the sensing device and provided to  
20 the computer system within a frame approximately thirty times per second. Alternatively, the  
21 sensing device may detect the location of beam impact on the target and include a signal  
22 processor and associated circuitry to provide impact location information in the form of X and  
23 Y coordinates to computer system 118 for processing in substantially the same manner  
24 described above. The computer system may further utilize any type of input device providing  
25 impact location or other information (e.g., a mouse to simulate firearm operation).

26 The image characteristics of the sensing device enable the device to capture images  
27 of the target including any changes to the target (e.g., beam impacts) occurring between  
28 successive frame transmissions. Thus, the sensing device facilitates detection of beam impact  
29 from laser transmitters having a pulse duration less than the frame rate (e.g., pulse durations  
30 as low as approximately one millisecond). The computer system may measure the pulse  
31 duration of a laser transmitter based on the quantity of succeeding frames containing a laser  
32 pulse. The system is typically configured for laser pulses having a duration of approximately

1 six milliseconds, and provides messages to a user when lasers having other pulse durations  
2 are utilized. The sensing device performs an internal initialization sequence where the frame  
3 rate is initially low and increases to the operational rate (e.g., approximately thirty frames per  
4 second). Computer system 118 measures the sensing device frame rate (e.g., determines the  
5 quantity of frames received per second) and delays system operation until the sensing device  
6 attains the operational rate. Calibrations are further performed by the system to align the  
7 sensing device and target, to define the target within the captured target images and to adjust  
8 for ambient light conditions as described below. A printer (not shown) may further be  
9 connected to the computer system to print reports containing user feedback information (e.g.,  
10 score, hit/miss information, etc.), while individual firearm training sessions may be stored.

11 The system may be utilized with various types of targets with target characteristics  
12 contained in several files that are stored on computer system 118. In particular, a desired  
13 target may be photographed and/or scanned prior to system utilization to produce several  
14 target files and target information as described above. Alternatively, a user may capture  
15 images of user generated targets via the sensing device and utilize computer system 118 or  
16 other computer system (e.g., via training system or conventional software) to produce the  
17 target files and target information for use by the system as described above. The target files  
18 include a parameter file, a display image file, a scoring image file, a print image file and a  
19 second display file, each substantially similar to the corresponding target file described above.  
20 The files are utilized by the system in substantially the same manner described above to  
21 provide scoring or other information, displays and printed reports. The produced files along  
22 with scaling and other information (e.g., produced based on user information, such as range)  
23 are stored on computer system 118 for use during system operation. An initial calibration is  
24 performed to correlate the target with the sensing device and computer system. Thus, the  
25 system may readily accommodate any type of target without interchanging system  
26 components. Moreover, target images may be downloaded from a network, such as the  
27 Internet, and printed for use with the system as described above. The downloaded target  
28 image may be utilized to generate target files as described above or the target files may  
29 similarly be available on the network and downloaded into the computer system. The network  
30 basically provides access to additional targets for use with the system.

31 Computer system 118 includes software to control system operation and provide a  
32 graphical user interface for displaying user performance. The manner in which the computer

1 system monitors beam impact locations and provides information to a user is illustrated in  
2 Figs. 6 - 8. Initially, computer system 118 (Fig. 5) performs calibrations at step 140.  
3 Basically, the computer system performs a mechanical calibration and a system calibration.  
4 The mechanical calibration generally facilitates alignment of the sensing device with the  
5 target and computer system, while the system calibration enables determination of parameters  
6 for system operation. In particular, the computer system preferably displays a calibration  
7 graphical user screen (Fig. 7) including a window 153 displaying the captured target images  
8 to initiate the calibrations. The computer system basically updates the captured target image  
9 displayed in the window with successive captured target images as they are received from the  
10 sensing device. The calibration screen further displays a series of substantially parallel  
11 horizontal lines 147 and a substantially central vertical line 149 overlaid with the received  
12 captured target images within window 153, coordinates of selected locations within window  
13 153, and screen input mechanisms (e.g., arrows, buttons, etc.) to enable a user to selectively  
14 adjust the displayed coordinates. Basically, sensing device 116 faces, but is typically  
15 positioned below, the target. Accordingly, the sensing device captures images of the target  
16 having an upward viewing angle. This angle causes the sensing device to produce generally  
17 trapezoidal images of the target, where the target lower section has greater transverse  
18 dimensions than those of the target upper section within the produced images. The computer  
19 system compensates for the device viewing angle and requests the user to indicate, preferably  
20 via a mouse or other input device, the corners of the target displayed by the captured target  
21 images within window 153 of the calibration screen. The coordinates for a corner designated  
22 by a user are displayed on the screen, where the user may selectively adjust the coordinates.  
23 This process is repeated for each corner to define for computer system 118 the target within  
24 the captured target images. The horizontal and vertical lines 147, 149 are adjusted in  
25 accordance with the entered information to indicate the system perspective of the target. The  
26 calibration may be repeated until horizontal lines 147 are substantially coincident the  
27 corresponding target horizontal edges and target horizontal center line and vertical line 149  
28 is substantially coincident the target vertical center line, thereby indicating alignment of the  
29 target with the system. Alternatively, the target or diffuser may include indicia (e.g., colored  
30 stickers in the form of dots or other shapes) indicating the target corners to enable the  
31 computer system to automatically define the target based on identifying the indicia within the  
32 captured target images received from sensing device 116. The computer system basically

1 correlates the captured target images with the target viewed by the user to determine the beam  
2 impact locations. In other words, the computer system compensates for the viewing angle of  
3 the sensing device with respect to that of the user to determine appropriate beam impact  
4 locations from the target image information.

5 The system sensitivity to the emitted beam and ambient light conditions may be  
6 selectively adjusted by the user or may be determined by computer system 118 based on  
7 measured conditions. Basically, the computer system determines a laser luminance or density  
8 value of the beam impact on the target from the target image information received from the  
9 sensing device. Specifically, each captured target image includes a plurality of pixels each  
10 associated with red (R), green (G) and blue (B) values to indicate the color and luminance of  
11 that pixel. The red, green and blue values for each pixel are multiplied by a respective  
12 weighting factor and summed to produce a pixel density. In other words, the pixel density  
13 may be expressed as follows:

14

15  $\text{Pixel Density} = (\text{R} \times \text{Weight1}) + (\text{G} \times \text{Weight2}) + (\text{B} \times \text{Weight3})$

16

17 where Weight1, Weight2 and Weight3 are weighting values that may be selected in any  
18 fashion to enable the system to identify beam impact locations within the captured target  
19 images. The respective weights may have the same or different values and may be any types  
20 of values (e.g., integer, real, etc.). The beam impact location is considered to occur within a  
21 group of pixels within a captured image where each group member has a density value  
22 exceeding a threshold. Typically, the group of pixels containing or representing the beam  
23 impact form an area or shape. The pixel at the center of the area or shape formed by the pixel  
24 group is considered by the system to contain, or represent the location of, a beam impact.  
25 Since target images are being repeatedly captured and transmitted to the computer system at  
26 the sensing device operational rate (e.g., approximately thirty frames per second), certain  
27 captured target images may not contain any beam impact detections. Accordingly, the  
28 threshold basically controls the system sensitivity to the emitted beam in relation to the  
29 ambient light, and enables the system to determine the presence of a beam impact within a  
30 captured target image. The threshold is generally increased to reduce the quantity of false hits  
31 detected by the system during system operation. The computer system determines maximum  
32 and average density values from the captured target image pixel values and adjusts the

1 threshold accordingly. The pixel density values of each captured target image may  
2 additionally be accumulated and/or averaged to provide an indication of the ambient light  
3 condition or luminance.

4 During calibration, the computer system requests the user to actuate firearm 6 and  
5 project a beam onto the target. Alternatively, the calibration may utilize data collected during  
6 system operation as described below. The computer system receives captured target images  
7 from the sensing device and automatically determines the detection speed of the sensing  
8 device, the ambient light condition and the laser density threshold as described above. These  
9 parameters may be displayed in the form of color displays indicating that the parameter values  
10 are within acceptable tolerances or the parameter values may be displayed in terms of a  
11 percentage (e.g., a percentage of the maximum acceptable values for the parameters).  
12 However, the values may be displayed in any desired fashion. Further, the calibration screen  
13 may display horizontal and vertical positional offsets that may be utilized by the computer  
14 system to determine beam impact locations. The determined threshold value as well as any  
15 desired positional offsets (e.g., horizontal and or vertical) may be selectively adjusted by the  
16 user via the mouse or other input device. For example, the threshold value may be set by the  
17 user to a high, medium or low setting via a user screen pull down list or other input devices  
18 to achieve a desired system sensitivity with respect to the amount of ambient light present  
19 during system operation.

20 The computer system may further automatically determine the threshold in the manner  
21 described above in response to detecting changes in light conditions during system operation.  
22 In particular, the computer system determines density values for the pixels of each captured  
23 target image during system operation. The values are accumulated and/or averaged to provide  
24 a lighting value representing the ambient light condition. If the lighting value achieves levels  
25 outside an acceptable range, computer system 118 interrupts system operation to determine  
26 a new threshold value. The computer system typically waits for the light conditions to  
27 produce acceptable lighting values prior to determining a new threshold. The settings  
28 determined by the calibrations and/or selected by the user may be stored by the computer  
29 system for later utilization by the system, thereby obviating the need to re-calibrate the system  
30 when conditions remain in substantially the same state (e.g., lighting condition, position of  
31 sensing device, etc.). The mechanical and system calibrations are typically performed at  
32 system initialization, but may be initiated by a user via computer system 118.

1       Once the calibrations are completed, a user may commence projecting the laser beam  
2 from the firearm toward the target. Sensing device 116 captures target images at step 142,  
3 and transmits the captured target images to computer system 118 for processing at step 144.  
4       The computer system processes the captured target images to determine a beam impact  
5 location at step 146. Specifically, each captured target image received from the sensing  
6 device includes a plurality of pixels each associated with red (R), green (G) and blue (B)  
7 values to indicate the color and luminance of that pixel as described above. The red, green  
8 and blue values for each pixel are multiplied by a respective weighting factor and summed to  
9 produce a pixel density as described above.

10      A beam impact is considered to occur within a pixel group of a captured target image  
11 where each group member has a density value exceeding a threshold. The pixel group forms  
12 an area or shape where the center pixel of that area or shape is considered by the system to  
13 contain, or represent the location of, the beam impact. If the density value of each captured  
14 image pixel is less than the threshold, the captured target image is not considered to include  
15 a beam impact. When the computer system identifies a pixel containing a beam impact, the  
16 coordinates (e.g., X and Y coordinates) of that pixel within the captured target image are  
17 determined by the computer system. These coordinates represent the location of a beam  
18 impact within the captured target image and are subsequently processed to compensate for the  
19 sensing device viewing angle. In other words, the captured target image coordinates are  
20 converted from a generally trapezoidal target image produced by the sensing device viewing  
21 angle to coordinates within a generally rectangular target image representing the view of the  
22 user and the scoring and display files.

23      The computer system includes several target files having target information and scaled  
24 images as described above. Since the scaling of the scoring and display images are  
25 predetermined, the computer system translates the resulting processed or converted  
26 coordinates into the respective scoring and display image coordinate spaces at step 148.  
27      Basically, the scoring and display images each utilize a particular quantity of pixels for a given  
28 measurement unit (e.g., millimeter, centimeter, etc.), while the quantity of pixels for the target  
29 is determined from the trapezoidal target image. The ratios of the pixel quantities between  
30 the target and each of the scoring and display images are determined and applied to the  
31 processed or converted coordinates to produce translated coordinates within each of the  
32 respective scoring and display image coordinate spaces.

1        In addition, the computer system may determine the pulse width of the laser beam as  
2 described above and provide messages in response to a user utilizing a laser having an  
3 unsuitable pulse width with respect to the system configuration. The system preferably is  
4 configured for laser transmitters emitting a pulse having a duration of six milliseconds, and  
5 can be utilized with laser pulses having a duration as low as one millisecond. However, the  
6 system may be utilized and/or configured for operation with laser transmitters having any  
7 desired pulse width.

8        The translated coordinates for the scoring image are utilized to determine the score or  
9 other activity information for the beam impact at step 150. Specifically, the translated  
10 coordinates identify a particular location within the scoring image. Various sections of the  
11 scoring image are color coded to indicate a value or other activity information associated with  
12 that section as described above. The color of the location within the scoring image identified  
13 by the translated coordinates is ascertained to indicate the value or other activity information  
14 for the beam impact. The scoring factor within the parameter file is applied to (e.g.,  
15 multiplied by) the score value to determine a score for the beam impact. The score and other  
16 impact information is determined and stored in a database or other storage structure, while a  
17 computer system display showing the target is updated to illustrate the beam impact location  
18 and other information (e.g., natural dispersion, center of mass, caliber, impact score,  
19 cumulative score, score percentage, elapsed time, time between shots, etc.) at step 152. The  
20 display image is displayed, while the beam impact location is identified by indicia that are  
21 overlaid with the display image and placed in an area encompassing the translated display  
22 image coordinates. The indicia may be scaled to reflect the caliber of the firearm. In addition,  
23 the computer system may provide audio (e.g., resembling firearm shots and/or hits) to indicate  
24 beam impact. An exemplary graphical user screen indicating the target, beam impact  
25 locations, impact time, score and other information is illustrated in Fig. 8. The system is  
26 preferably configured to detect, process and display up to approximately four shots per  
27 second, but may be adjusted to accommodate any desired shooting rate.

28       If a round or session of firearm activity is not complete as determined at step 154, the  
29 user continues actuation of the firearm and the system detects beam impact locations and  
30 determines information as described above. However, when a round or session is determined  
31 to be complete at step 154, the computer system retrieves information from the database and  
32 determines information pertaining to the round at step 156. The computer system may further

1 determine grouping circles. These are generally utilized on shooting ranges where projectile  
2 impacts through a target must all be within a circle of a particular diameter (e.g., four  
3 centimeters). The computer system may analyze the beam impact information and provide  
4 groupings and other information on the display that is typically obtained during activities  
5 performed on firing ranges (e.g., dispersion, etc.). The grouping circle and beam impact  
6 location indicia are typically overlaid with the display image and placed in areas  
7 encompassing the appropriate coordinates of the display image space in substantially the same  
8 manner described above.

9       When a report is desired as determined at step 158, the computer system retrieves the  
10 appropriate information from the database and generates a report for printing at step 160. The  
11 report includes the print image, while beam impact location coordinates are retrieved from the  
12 database and translated to the print image coordinate space. The translation is accomplished  
13 utilizing ratios of pixel quantities for a given measurement unit between the target and the  
14 print image in substantially the same manner described above. The beam impact locations are  
15 identified by indicia that are overlaid with the print image and placed in an area encompassing  
16 the translated print image coordinates as described above for the display. The report further  
17 includes various information pertaining to user performance (e.g., score, dispersion, center of  
18 mass, caliber, impact score, cumulative score, score percentage, elapsed time, time between  
19 shots, etc.). When another round is desired, and a calibration is requested at step 164, the  
20 computer system performs the calibrations at step 140 and the above process of system  
21 operation is repeated. Similarly, the above process of system operation is repeated from step  
22 142 when another round is desired without performing a calibration. System operation  
23 terminates upon completion of the training or qualification activity as determined at step 162.

24       The system may additionally provide a trace feature similar to the trace feature  
25 described above. In particular, the trace feature is enabled in response to the laser transmitter  
26 assembly operating in a “constant on” mode. When the computer system detects the laser  
27 beam continuously for a predetermined time interval (e.g., the laser is detected within a  
28 predetermined quantity of consecutive frames of target image information as described  
29 above), preferably greater than approximately one-hundred milliseconds, the computer system  
30 displays a flashing block on the graphical user screen (Fig. 8). The block follows movement  
31 of the firearm or laser beam projected on the target. Basically, the computer system  
32 determines coordinates of laser beam impact locations from target image information received

1 from the sensing device and translates those coordinates to display image coordinates as  
2 described above. The position of the block is adjusted on the display in accordance with the  
3 translated coordinates. As the firearm or laser beam alters position, the block is similarly  
4 adjusted on the display to visually indicate movement of the firearm. The system preferably  
5 displays the previous ten beam impact locations to enable a user to view the movement.  
6 However, any quantity of previous locations may be displayed. In addition, the size of target  
7 100 (Fig. 5) may be scaled to simulate firearm training at various ranges. The particular range  
8 may be entered into computer system 118, while the target may be scaled to a particular size  
9 to reflect conditions at a prescribed range. The computer system may adjust for range during  
10 calibration and operates as described above with a user positioned at a corresponding scaled  
11 distance from the target. The laser transmitter emits a beam (e.g., the laser beam has a peak  
12 power output of approximately one milliwatt) that may be detected by the system at a range  
13 of up to approximately thirty feet. However, laser transmitters having greater power may be  
14 utilized for extended ranges.

15 Operation of the system is described with reference to Fig. 5. Initially, system case  
16 180 is positioned at a suitable location by the user. The case is opened and a target is selected  
17 and placed along with diffuser 188 in flap 189 of upper member 182 as described above.  
18 System software and/or target files are installed on computer system 118 as described above  
19 (e.g., if the software is not currently resident on the computer system or a new target is being  
20 utilized) and sensing device 116 is connected to the computer system via cable 194. Laser  
21 transmitter rod 3 is connected to laser module 4 and inserted into barrel 8 of firearm 6 as  
22 described above. The laser module is actuated in response to depression of firearm trigger 7.  
23 The computer system is commanded to commence a firearm activity, and initially performs  
24 calibrations subsequent initialization of sensing device 116 as described above. Once the  
25 calibrations are complete, the firearm may be actuated by a user, while the sensing device  
26 captures images of the target and provides target image information to the computer system  
27 as described above. The computer system determines the coordinates of beam impact  
28 locations within the target from the received captured target images as described above and  
29 translates those coordinates into the respective scoring and display image spaces. The  
30 computer system further determines a score value corresponding to the impacted target section  
31 and other information for storage in a database as described above. The impact location and  
32 other information are displayed on a graphical user screen (Fig. 8) as described above. When

1 a round is complete, the computer system retrieves the stored information and determines  
2 information pertaining to the round for display on the graphical user screen. Moreover, a  
3 report may be printed providing information relating to user performance as described above.  
4 In addition, the system may provide indicia on the display to indicate and trace firearm  
5 movement as described above.

6 It will be appreciated that the embodiments described above and illustrated in the  
7 drawings represent only a few of the many ways of implementing a firearm laser training  
8 system and method facilitating firearm training with various targets and visual feedback of  
9 simulated projectile impact locations.

10 The systems may include any quantity or type of target of any shape or size,  
11 constructed of any suitable materials and placed in any desired location. The computer  
12 systems may be implemented by any conventional or other computer or processing system.  
13 The components of the systems may be connected by any communications devices (e.g.,  
14 cables, wireless, network, etc.) in any desired fashion, and may utilize any type of  
15 conventional or other interface scheme or protocol. The computer systems may be in  
16 communication with other training systems via any type of communications medium (e.g.,  
17 direct line, telephone line/modem, network, etc.) to facilitate group training or competitions.  
18 The systems may be configured for any types of training, qualification, competition, gaming  
19 and/or entertainment applications. The printers may be implemented by any conventional or  
20 other type of printer.

21 The firearm laser training systems may be utilized with any type of firearm (e.g., hand-  
22 gun, rifle, shotgun, machine gun, etc.), while the laser module may be fastened to the firearm  
23 at any suitable locations via any conventional or other fastening techniques (e.g., frictional  
24 engagement with the barrel, brackets attaching the device to the firearm, etc.). Further, the  
25 systems may include a dummy firearm projecting a laser beam, or replaceable firearm  
26 components (e.g., a barrel) having a laser device disposed therein for firearm training. The  
27 replaceable components (e.g., barrel) may further enable the laser module to be operative with  
28 a firearm utilizing any type of blank cartridges. The laser assembly may include the laser  
29 module and rod or any other fastening device. The laser module may emit any type of laser  
30 beam. The laser module housing may be of any shape or size, and may be constructed of any  
31 suitable materials. The opening may be defined in the module housing at any suitable  
32 locations to receive the rod. Alternatively, the housing and rod may include any conventional

1 or other fastening devices (e.g., integrally formed, threaded attachment, hook and fastener,  
2 frictional engagement with the opening, etc.) to attach the module to the rod. The optics  
3 package may include any suitable lens for projecting the beam. The laser beam may be  
4 enabled for any desired duration sufficient to enable the sensing device to detect the beam.  
5 The laser module may be fastened to a firearm or other similar structure (e.g., a dummy, toy  
6 or simulated firearm) at any suitable locations (e.g., external or internal of a barrel) and be  
7 actuated by a trigger or any other device (e.g., power switch, firing pin, relay, etc.). Moreover,  
8 the laser module may be configured in the form of ammunition for insertion into a firearm  
9 firing or similar chamber and project a laser beam in response to trigger actuation.  
10 Alternatively, the laser module may be configured for direct insertion into the barrel without  
11 the need for the rod. The laser module may include any type of sensor or detector (e.g.,  
12 acoustic sensor, piezoelectric element, accelerometer, solid state sensors, strain gauge, etc.)  
13 to detect mechanical or acoustical waves or other conditions signifying trigger actuation. The  
14 laser module components may be arranged within the housing in any fashion, while the  
15 module power source may be implemented by any type of batteries. Alternatively, the module  
16 may include an adapter for receiving power from a common wall outlet jack or other power  
17 source. The laser beam may be visible or invisible (e.g., infrared), may be of any color or  
18 power level, may have a pulse of any desired duration and may be modulated in any fashion  
19 (e.g., at any desired frequency or unmodulated) or encoded in any manner to provide any  
20 desired information, while the transmitter may project the beam continuously or include a  
21 "constant on" mode. The system may be utilized with transmitters and detectors emitting any  
22 type of energy (e.g., light, infrared, etc.).

23 The laser transmitter rod may be of any shape or size, and may be constructed of any  
24 suitable materials. The rod may include dimensions to accommodate any firearm caliber. The  
25 rings may be of any shape, size or quantity and may be constructed of any suitable materials.

26 The rings may be disposed at any locations along the rod and may be implemented by any  
27 devices having adjustable dimensions. The stop may be of any shape or size, may be disposed  
28 at any suitable locations along the rod and may be constructed of any suitable materials. The  
29 post may be of any shape or size, may be disposed at any suitable locations on the rod, and  
30 may be constructed of any suitable materials. The post or rod may include any conventional  
31 or other fastening devices to attach the laser module to the rod.

32 The targets may be implemented by any type of target having any desired configuration

1 and indicia forming any desired target site. The targets may be of any shape or size, and may  
2 be constructed of any suitable materials. The targets may include any conventional or other  
3 fastening devices to attach to any supporting structure. Similarly, the supporting structure  
4 may include any conventional or other fastening devices to secure a target to that structure.  
5 Alternatively, any type of adhesive may be utilized to secure a target to the structure. The  
6 support structure may be implemented by any structure suitable to support or suspend a target.  
7 The targets may include any quantity of sections or zones of any shape or size and associated  
8 with any desired values. The targets may include any quantity of individual targets or target  
9 sites. The systems may utilize any type of coding, color or other scheme to associate values  
10 with target sections (e.g., table look-up, target location identifiers as keys into a database or  
11 other storage structure, etc.). Further, the sections or zones may be identified by any type of  
12 codes, such as alphanumeric characters, numerals, etc., that indicate a score value or any other  
13 information. The score values may be set to any desired values.

14 The target characteristics and images may be contained in any quantity of any types  
15 of files. The target images may be scaled in any desired fashion. The coordinate translations  
16 may be accomplished via any conventional or other techniques, and may be performed by the  
17 sensing devices and/or computer systems. The target files may contain any information  
18 pertaining to the target (e.g., filenames, images, scaling information, indicia size, etc.). The  
19 target files may be produced by the computer systems or other processing system via any  
20 conventional or other software and placed on the computer systems for operation.  
21 Alternatively, the target files may reside on another processing system accessible to the  
22 computer systems via any conventional or other communications medium (e.g., network,  
23 modem/telephone line, etc.), or be available on any type of storage medium.

24 The system case may be of any size or shape and may be constructed of any suitable  
25 materials. The case may be placed at any desired location and include any quantity of any  
26 system components and/or accessories. The upper and lower members may be of any shape  
27 or size and may be constructed of any suitable materials. These members may include any  
28 quantity of any types of conventional or other fastening, pivoting and support devices  
29 disposed at any suitable locations. Further, the case may include any quantity of any types of  
30 handles and/or other transporting devices (e.g., wheels, casters, etc.) disposed at any suitable  
31 locations to facilitate transport of the case. The upper and lower members may store any  
32 quantity of any system components or accessories, and may include any type of insulation

1 material (e.g., foam). The upper and lower members may include any quantity of  
2 compartments of any shape or size and arranged in any fashion to store the system  
3 components and/or accessories. The system components and/or accessories may be disposed  
4 in any quantity and/or combination in the case in any desired arrangement.

5 The upper and lower members may be positioned at any desired angle relative to each  
6 other during system operation. The components of the systems may be utilized as described  
7 above within or external of a case. The sensing device of the alternative system may be  
8 utilized with any quantity or types of stands, while the laser transmitter assembly may utilize  
9 any type of tool to facilitate adjustments. The cable may be implemented by any conventional  
10 or other cable to connect the sensing device to the computer system. The flap may be of any  
11 shape or size, may be constructed of any suitable materials and may be disposed at any  
12 suitable locations within the case. The diffuser may be of any shape or size, may be  
13 constructed of any suitable materials, may have any degree of transparency and may be  
14 disposed at any suitable location with respect to the target and laser transmitter assembly. The  
15 system may alternatively utilize the target without the diffuser.

16 The sensing devices may be implemented by any conventional or other sensing device  
17 (e.g., camera, CCD, matrix or array of light sensing elements, etc.) suitable for detecting the  
18 laser beam and/or capturing a target image. The filter may be implemented by any  
19 conventional or other filter having filtering properties for any particular frequency or range  
20 of frequencies. The sensing devices may employ any type of light sensing elements, and may  
21 utilize a grid or array of any suitable dimension. The sensing devices may be of any shape or  
22 size, and may be constructed of any suitable materials. The sensing devices may be supported  
23 by any mounting device (e.g., a tripod, a mounting post, etc.) and positioned at any suitable  
24 locations providing access to the targets. The calibrations may utilize any quantity of  
25 locations to define the target area, and may map the area to any sized array. The calibration  
26 locations may be any suitable locations within or outside the target confines. Alternatively,  
27 the sensing devices may be positioned at any suitable locations within or external of a case  
28 and at any desired viewing angle relative to a target. The sensing devices may be coupled to  
29 any port of the computer systems via any conventional or other device (e.g., cable, wireless,  
30 etc.). The sensing devices may provide color or black and white (e.g., gray scale) images to  
31 the computer systems and have any desired frame rate. Alternatively, the sensing devices may  
32 include processing circuitry to detect beam impact locations and provide coordinates of those

1 locations to the computer systems. The sensing devices may be configured to detect any  
2 energy medium having any modulation, pulse or frequency. Similarly, the laser may be  
3 implemented by a transmitter emitting any suitable energy wave. The sensing devices may  
4 detect the laser beam continuously for any desired interval to initiate a tracing mode. The  
5 sensing devices may transmit any type of information to the computer system to indicate beam  
6 impact locations, while the computer systems may process any type of information (e.g., X  
7 and Y coordinates, image information, etc.) from the sensing devices to display and provide  
8 feedback information to the user.

9 It is to be understood that the software for the computer systems may be implemented  
10 in any desired computer language and could be developed by one of ordinary skill in the  
11 computer arts based on the functional descriptions contained in the specification and flow  
12 charts illustrated in the drawings. The computer systems may alternatively be implemented  
13 by any type of hardware and/or other processing circuitry. The various functions of the  
14 computer systems may be distributed in any manner among any quantity of software modules,  
15 processing systems and/or circuitry (e.g., including those within the sensing devices). The  
16 software and/or algorithms described above and illustrated in the flow charts may be modified  
17 in any manner that accomplishes the functions described herein. The databases may be  
18 implemented by any conventional or other database or storage structure (e.g., file, data  
19 structure, etc.).

20 The display screens and reports may be arranged in any fashion and contain any type  
21 of information. The various parameter or other values may be displayed in the report and/or  
22 on the screens in any manner (e.g., charts, bars, etc.) and in any desired form (e.g., actual  
23 values, percentages, etc.), while any of the values displayed on the screens may be adjusted  
24 by the user via any desired input mechanisms. The calibration screen may include any  
25 quantity of any types of indicia of any shape, color or size to facilitate alignment of the  
26 sensing device with the target and computer system. Alternatively, the computer system  
27 image may be adjusted for alignment with the sensing device and target. The target may be  
28 defined within the captured target image in any desired manner via any suitable input  
29 mechanisms. The target may be defined at any suitable locations within the captured target  
30 image or window, while the selected locations may be indicated by any quantity of any types  
31 of indicia of any shape, color or size. Alternatively, the target definition may be accomplished  
32 automatically by positioning any quantity of indicia of any color, shape or size on the target

1 and/or diffuser at any suitable locations to define the target for the computer system.

2       The density value may be determined with any weights having any desired value or  
3 types of values (e.g., integer, real, etc.). The weights and pixel component values may be  
4 utilized in any desired combination to produce a pixel density. Alternatively, any quantity of  
5 pixel values within any quantity of images may be manipulated in any desired fashion (e.g.,  
6 accumulated, averaged, multiplied by each other or weight values, etc.) to determine the  
7 presence and location of a beam impact within an image. Further, any quantity of density  
8 and/or pixel values within any quantity of images may be manipulated in any desired fashion  
9 (e.g., accumulated, averaged, multiplied by each other or weight values, etc.) to determine the  
10 threshold and light conditions. The threshold may be determined periodically or in response  
11 to any desired light or other conditions (e.g., light conditions are outside any desired range or  
12 have any desired change in value, etc.), and may be set by the computer system and/or user  
13 to any desired value. The systems may alternatively utilize gray scale or any type of color  
14 images (e.g., pixels having gray scale, RGB or other values) and manipulate any quantity of  
15 pixel values within any quantity of images in any desired fashion to determine the threshold,  
16 light conditions and presence and location of a beam impact.

17       The indicia indicating beam impact locations and other information may be of any  
18 quantity, shape, size or color and may include any type of information. The indicia may be  
19 placed at any locations and be incorporated into or overlaid with the target images. The  
20 systems may produce any desired type of display or report having any desired information.  
21       The computer systems may determine scores or other activity information based on any  
22 desired criteria. The computer systems may poll the sensing devices or the sensing devices  
23 may transmit images and/or coordinates at any desired intervals for the tracing mode or  
24 sensing functions. The sensing devices may detect the laser beam continuously for any desired  
25 interval to initiate the tracing mode. The indicia for the tracing mode may be of any quantity,  
26 shape, size or color and may include any type of information. The tracing indicia may be  
27 placed at any locations and be incorporated into or overlaid with the target images. The  
28 tracing indicia may be flashing or continuously appearing on the display. The trace mode may  
29 display any quantity of previous impact locations to show movement of the firearm.

30       The systems may be configured for use with a transmitter emitting a laser beam having  
31 any desired pulse width, and may provide any type of message or other indication when the  
32 pulse width of a laser beam detected by the system is not compatible with the system

1 configuration. The systems may be configured to detect and process beam impact locations  
2 at any desired shot rate. The systems may utilize any conventional or other techniques to  
3 convert between the various image spaces, and may compensate for any desired sensing  
4 device position and/or viewing angle. The systems may be utilized with targets scaled in any  
5 fashion to simulate conditions at any desired ranges, and may utilize lasers having sufficient  
6 power to be detected at any desired scaled range.

7 It is to be understood that the terms "top", "bottom", "side", "upper", "lower", "front",  
8 "rear", "horizontal", "vertical" and the like are used herein merely to describe points of  
9 reference and do not limit the present invention to any specific configuration or orientation.

10 The present invention is not limited to the applications disclosed herein, but may be  
11 utilized for any type of firearm training, qualification, competition, gaming or entertainment  
12 applications.

13 From the foregoing description, it will be appreciated that the invention makes  
14 available a novel firearm laser training system and method facilitating firearm training with  
15 various targets and visual feedback of simulated projectile impact locations wherein the  
16 system scans a target to determine locations of laser beam or simulated projectile impacts on  
17 the target and provides a display of the simulated impact locations on the target with  
18 information corresponding to user performance.

19 Having described preferred embodiments of a new and improved firearm laser training  
20 system and method of facilitating firearm training with various targets and visual feedback of  
21 simulated projectile impact locations, it is believed that other modifications, variations and  
22 changes will be suggested to those skilled in the art in view of the teachings set forth herein.  
23 It is therefore to be understood that all such variations, modifications and changes are  
24 believed to fall within the scope of the present invention as defined by the appended claims.